

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

100 10/018776

225/30785

PCT/P10

27 DEC 2001

U.S. APPLICATION NO. (if known, see 37 CFR 1.5)

INTERNATIONAL APPLICATION NO.

INTERNATIONAL FILING DATE

PRIORITY DATE CLAIMED

PCT/EP00/04895

May 30, 2000

June 29, 1999

TITLE OF INVENTION

JOINING CONNECTION, METHOD FOR PRODUCING THE SAME AND A STEERING COLUMN FOR MOTOR VEHICLES COMPRISING SUCH A JOINING CONNECTION

APPLICANT(S) FOR DO/EO/US

Bernd FRIEWALD, Torsten HARMS, Hartmut KAHNERT, Olaf SATTLER

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
 2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
 3. ☐ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay Examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
 4. ☐ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
 5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2)).
 - a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
 - b. ☒ has been transmitted by the International Bureau
 - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US)
 6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
 7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3)).
 - a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
 - b. ☐ have been transmitted by the International Bureau.
 - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
 - d. ☐ have not been made and will not be made.
 8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
 9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)) (Unexecuted), 3 pgs.)
 10. ☒ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).
- Item 11. to 16. below concern other document(s) or information included:**
11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
 12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
 13. ☒ A **FIRST** preliminary amendment.
☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
 14. ☒ A substitute specification and marked-up copy thereof.
 15. ☐ A change of power of attorney and/or address letter.
 16. ☐ Other items or information:
 - a. PCT/IB/308
 - b. PCT/RO/101
 - c. PCT/IPEA/409
 - d. Two (2) Sheets Formal Drawings (Figs. 1-4)

U.S. APPLICATION NO. 10/018726		INTERNATIONAL APPLICATION NO. PCT/EP00/04895		ATTORNEY'S DOCKET NUMBER 225/50785	
17. <input checked="" type="checkbox"/> The following fees are submitted:				CALCULATIONS	PTO USE ONLY
Basic National Fee (37 CFR 1.492(a)(1)-(5)):					
Search Report has been prepared by the EPO or JPO \$ 890.00				890.00	
International preliminary examination fee paid to USPTO (37 CFR 1.482) \$ 690.00					
No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) \$ 740.00					
Neither international preliminary examination fee (37 CFR 1.48.2) nor International search fee (37CFR 1.445(a)(2)) paid to USPTO \$ 1000.00					
International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) \$ 100.00					
ENTER APPROPRIATE BASIC FEE AMOUNT = \$ 890.00					
Surcharge of \$130.00 for furnishing the oath or declaration later than [] 20 [X] 30 months from the earliest claimed priority date (37 CFR 1.492(e)).				\$130.00	
Claims	Number Filed	Number Extra	Rate		
Total Claims	18- 20 =	0	X \$18.00	\$	
Independent Claims	6- 3 =	3	X \$84.00	\$252.00	
Multiple dependent claims(s) (if applicable)			+ \$280.00	\$	
TOTAL OF ABOVE CALCULATIONS=				\$1272.00	
Applicant claims Small Entity Status (See 37 CFR §1.27) [] yes [] no.					
Reduction by 1/2 for filing by small entity, if applicable.				\$	
SUBTOTAL =				\$1272.00	
Processing fee of \$130.00 for furnishing the English translation later than [] 20 [] 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				\$	
TOTAL NATIONAL FEE =				\$1272.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28.3.31). \$40.00 per property +				\$	
TOTAL FEE ENCLOSED =				\$1272.00	
Amount to be refunded				\$	
Charged				\$	
a. <input checked="" type="checkbox"/> One check in the amount of \$1272.00 for the filing fee is enclosed					
b. <input type="checkbox"/> Please charge my Deposit Account No. _____ in the amount of \$ _____ to cover the above fees. A duplicate copy of this sheet is enclosed.					
c. <input checked="" type="checkbox"/> The Commissioner is hereby authorized to charge any additional fees, which may be required, or credit any overpayment to Deposit Account No. <u>05-1323</u> . A duplicate copy of this sheet is enclosed.					
NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.					
SEND ALL CORRESPONDENCE TO:					
Crowell & Moring, L.L.P.			SIGNATURE		
P.O. Box 14300			Robert L. Grabarek, Jr.		
Washington, D.C. 20044-4300			NAME		
Tel. No. (202) 624-2500			Registration No. 40,625		
Fax No. (202) 628-8844			REGISTRATION NUMBER		
			December 27, 2001		
			DATE		

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: BERND FREIWALD ET AL.
Serial No.: To Be Assigned
Filed: December 27, 2001 PCT No.: PCT/EP00/04895
Title: JOINING CONNECTION, METHOD FOR PRODUCING THE
SAME AND A STEERING COLUMN FOR MOTOR VEHICLES
COMPRISING SUCH A JOINING CONNECTION

PRELIMINARY AMENDMENT

Box PCT
Commissioner for Patents
Washington, D.C. 20231

Sir:

Please enter the following amendments to the specification, claims and abstract, as amended by way of Annexes to the International Preliminary Examination Report for PCT/EP00/04895, prior to the examination of the application during the U.S. National Phase.

IN THE SPECIFICATION:

Submitted herewith is a substitute specification and marked-up copy thereof which includes the changes made by way of the Annexes to the International Preliminary Examination Report.

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IN THE CLAIMS:

Please AMEND claims 1-15 as follows:

1. (AMENDED) A joining connection comprising a circumferentially closed hollow profile and an add-on part which defines a passage opening, and, on an inside of the passage opening, defines a recess which is spaced away from end sides of the add-on part, wherein the add-on part is slid with the passage opening onto the hollow profile and jammed to the hollow profile in this sliding-fit position by an expansion of the hollow profile, the expansion being formed by internal high-pressure deformation, and further wherein the add-on part consists of a material of lower yield strength than a material of the hollow profile, and the add-on part is only jammed to the hollow profile locally at a location of the recess.

2. (AMENDED) The joining connection according to Claim 1, wherein the recess is an annular freely turned recess.

3. (AMENDED) The joining connection according to Claim 1, wherein the hollow profile consists of a ductile steel material, preferably of St 37 or St 52, and the add-on part consists of a casting material, of a die casting or injection molding, preferably of ZnAl4Cu1, or of a lower-strength steel or of a light metal material.

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4. (AMENDED) The joining connection according to Claim 1, wherein the recess is of curved design with a shallow rise extending from a base to opposing edges of the recess.

5. (AMENDED) The joining connection according to Claim 1, wherein an expanded point of the hollow profile bears in an exact manner against a wall defining the recess.

6. (AMENDED) A method for producing a joining connection between a circumferentially closed hollow profile and an add-on part which is provided with a passage opening, a recess which is spaced away from end sides of the add-on part being formed on an inside of the passage opening, comprising the steps of sliding the add-on part with its passage opening onto the hollow profile, and expanding the hollow profile, in the sliding-fit position reached, by a fluidic internal high pressure delivered by an expansion lance inserted into the hollow profile, in such a manner that the hollow profile is jammed immovably to the add-on part, wherein the add-on part is comprised of a material of lower yield strength than a material of the hollow profile, and wherein the hollow profile is only expanded into the recess locally.

7. (AMENDED) The method according to Claim 6, wherein the recess is of curved design with a shallow rise from a base to opposing edges of the

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recess, and wherein the hollow profile is expanded until it bears completely against a wall defining the recess.

8. (AMENDED) The method according to Claim 6, wherein the add-on part is cast as a cast part having a discarded core and wherein the recess is cast at the same time as the add-on part.

9. (AMENDED) The method according to Claim 6, wherein the add-on part is injection molded or die cast and the recess is subsequently freely turned.

10. (AMENDED) The method according to Claim 6, wherein the add-on part is formed, in particular forged, from a low-strength steel, and wherein the recess is then engraved, turned or milled out from the add-on part.

11. (AMENDED) A steering column of a motor vehicle comprising a casing tube which surrounds a steering spindle and forms a hollow profile, and a holder, constituting an add-on part, for example for a steering column switch, the holder joined onto the casing tube, wherein the holder, which consists of a material of lower yield strength than a material of the casing tube, defines a circumferentially closed passage opening and is slid onto the casing tube, the passage opening having, on an inside, at least one recess which is spaced away from end sides of the holder, which end sides lie transversely with respect to a

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longitudinal direction of the casing tube, and wherein the casing tube has a locking element which, in the sliding-fit position of the holder, is shaped radially from a wall of the holder locally at a location of the recess by a fluidic internal high pressure and is jammed in the recess as a consequence of a shape of the locking element, forming a non-releasable joining connection between the holder and the casing tube.

12. (AMENDED) The steering column according to Claim 11, wherein the locking element bears over an entire surface against a wall defining the recess.

13. (AMENDED) The steering column according to Claim 11, wherein the recess is formed by an annular groove and the locking element is formed by an annular bead.

14. (AMENDED) The steering column according to Claim 11, wherein the casing tube consists of a ductile steel material, preferably of St 37 or St 52, and the holder consists of a casting material or of an injection molding or die casting, preferably of ZnAl4Cu, or of a low-strength steel or of a light metal material.

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15. (AMENDED) The steering column according to Claim 11, wherein the recess is of curved design with a shallow rise from a base to opposing edges of the recess.

Please ADD new claims 16-18 as follows:

16. (NEW) A joining connection comprising:

a circumferentially closed hollow profile; and

an add-on part defining a passage opening wherein an inside of the passage opening includes a recess which is spaced away from end sides of the add-on part;

wherein the circumferentially hollow profile is disposed within the passage opening of the add-on part and wherein the hollow profile is joined to the add-on part by an expanded portion of the hollow profile, the expanded portion of the hollow profile only received within the recess defined by the add-on part; and

further wherein the add-on part is comprised of a material of lower yield strength than a material of the hollow profile.

17. (NEW) A method for producing a connection between a circumferentially closed hollow profile and an add-on part, the add-on part defining a passage opening wherein an inside of the passage opening includes a recess, comprising the steps of:

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disposing the hollow profile within the passage opening of the add-on part;
and

expanding the hollow profile by a fluidic internal high pressure delivered by an expansion lance inserted into the hollow profile wherein the hollow profile is only expanded into the recess, the recess spaced away from end sides of the add-on part;

wherein the add-on part is comprised of a material of lower yield strength than a material of the hollow profile.

18. (NEW) A steering column of a motor vehicle comprising:

a casing tube forming a hollow profile; and

a holder defining a circumferentially closed passage opening wherein an inside of the passage opening includes a recess which is spaced away from end sides of the holder;

wherein the casing tube is disposed within the passage opening of the holder and locked in position within the holder by a locking element of the casing tube that is received within the recess of the holder, the locking element of the casing tube shaped radially by a wall of the holder defining the recess and a fluidic internal high pressure applied to the casing tube, the formed locking element jammed in the recess; and

wherein the holder is comprised of a material of lower yield strength than a material of the casing tube.

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(A copy of the marked-up version of amended claims 1-15 attached to this Preliminary Amendment).

IN THE ABSTRACT:

Please substitute the new Abstract of the Disclosure submitted herewith on a separate page for the original Abstract presently in the application.

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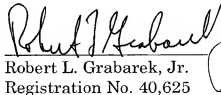
REMARKS

Entry of the amendments to the specification and claims, as amended by way of Annexes to the International Preliminary Examination Report for PCT/EP00/04895, before examination of the application in the U.S. National Phase is respectfully requested. If there are any questions regarding this Preliminary Amendment or this application in general, a telephone call to the undersigned would be appreciated since this should expedite the prosecution of the application for all concerned.

If necessary to effect a timely response, this paper should be considered as a petition for an Extension of Time sufficient to effect a timely response, and please charge any deficiency in fees or credit any overpayments to Deposit Account No. 05-1323 (Docket No. 225/50785).

Respectfully submitted,

Date: December 27, 2001


Robert L. Grabarek, Jr.
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CAM No.: 95309.281

Serial No.: To Be Assigned

ABSTRACT OF THE DISCLOSURE

A joining connection between a circumferentially closed hollow profile and an add-on part which is provided with a passage opening and consists of a material of lower strength than the material of the hollow profile is disclosed. Additionally, a method for producing the connection and to a steering column having this joining connection is disclosed. In order to connect a hollow profile and an add-on part having lower strength than the hollow profile non-releasably to each other in a simple, reproducible and reliable manner, and furthermore in order to reliably fit a holder as an add-on part to the casing tube of the steering column, where the holder has a lower strength than the casing tube, with a low outlay on components and costs and with exact, reproducible positioning of the two joining partners with respect to each other in the joining connection, a recess is provided which is spaced away from the end sides of the add-on part on the inside of the passage opening, to slide the add-on part with its passage opening onto the hollow profile and to jam it to the hollow profile in this sliding-fit position by a local expansion of the hollow profile. The expansion being formed by internal high-pressure deformation at the location of the recess.--

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

Please AMEND claims 1-15 as follows:

1. (AMENDED) [Joining] A joining connection [between] comprising a circumferentially closed hollow profile [(1)] and an add-on part [(2)] which [is provided with] defines a passage opening [(5)], and, on [the] an inside [(7)] of the passage opening, [(5), has] defines a recess [(10)] which is spaced away from [the] end sides [(8, 9)] of the add-on part [(2)], wherein the add-on part [(2) being] is slid with [its] the passage opening [(5)] onto the hollow profile [(1)] and [being] jammed to the [latter] hollow profile in this sliding-fit position by an expansion of the hollow profile, [(1), said] the expansion being formed by [means of] internal high-pressure deformation, [characterized in that] and further wherein the add-on part [(2)] consists of a material of lower yield strength than [the] a material of the hollow profile [(1)], and [in that] the add-on part [(2)] is only jammed to the hollow profile [(1)] locally at [the] a location of the recess [(10)].

2. (AMENDED) [Joining] The joining connection according to Claim 1, [characterized in that] wherein the recess [(10)] is an annular freely turned recess.

3. (AMENDED) [Joining] The joining connection according to Claim 1, [characterized in that] wherein the hollow profile [(1)] consists of a ductile steel material, preferably of St 37 or St 52, and the add-on part [(2)] consists of a

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casting material, of a die casting or injection [moulding] molding, preferably of ZnAl4CuI, or of a lower-strength steel or of a light metal material.

4. (AMENDED) [Joining] The joining connection according to Claim 1, [characterized in that] wherein the recess [(10)] is of curved design with a shallow rise extending from [its] a base [(15)] as far as its edges [(16)] to opposing edges of the recess.

5. (AMENDED) [Joining] The joining connection according to Claim 1, [characterized in that the] wherein an expanded point of the hollow profile [(1)] bears in an exact manner against [the walls (14)] of a wall defining the recess [(10)].

6. (AMENDED) [Method] A method for producing a joining connection between a circumferentially closed hollow profile [(1)] and an add-on part [(2)] which is provided with a passage opening [(5)], a recess [(10)] which is spaced away from [the] end sides [(8, 9)] of the add-on part [(2)] being formed on [the] an inside [(7)] of the passage opening, [(5), after which] comprising the steps of sliding the add-on part [(2)] is slid] with its passage opening [(5)] onto the hollow profile [(1)], and [subsequently] expanding the hollow profile [(1)], in the sliding-fit position reached, [is expanded,] by a fluidic internal high pressure [by means of] delivered by an expansion lance inserted into the hollow profile [(1)], in such a

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manner that the hollow profile [(1)] is jammed immovably to the add-on part [(2)], [characterized in that an] wherein the add-on part is comprised of a material of lower yield strength than [the] a material of the hollow profile [(1)] is used], and [in that] wherein the hollow profile [(1)] is only expanded into the recess [(10)] locally.

7. (AMENDED) [Method] The method according to Claim 6, [characterized in that] wherein the recess [(10)] is of curved design with a shallow rise from [its] a base [(15)] as far as its edges [(16)] to opposing edges of the recess, and [in that] wherein the hollow profile [(1)] is expanded until it bears completely against [the recess walls (14)] a wall defining the recess.

8. (AMENDED) [Method] The method according to Claim 6, [characterized in that] wherein the add-on part [(2)] is cast as a cast part having a discarded core[, and wherein the recess [(10)] being] is cast at the same time as the add-on part.

9. (AMENDED) [Method] The method according to Claim 6, [characterized in that] wherein the add-on part [(2)] is injection [moulded] molded or die cast and the recess [(10)] is subsequently freely turned.

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10. (AMENDED) [Method] The method according to Claim 6, [characterized in that] wherein the add-on part [(2)] is formed, in particular forged, from a low-strength steel, and [in that] wherein the recess [(10)] is then engraved, turned or milled out from the add-on part.

11. (AMENDED) [Steering] A steering column of a motor [vehicles having] vehicle comprising a casing tube which surrounds a steering spindle and forms a hollow profile, and a holder, constituting an add-on part, for example for a steering column switch, the holder [being] joined onto the casing tube, [characterized in that] wherein the holder [(2)], which consists of a material of lower yield strength than [the] a material of the casing tube, [(1), has] defines a circumferentially closed passage opening [(5)] and is slid [with the latter] onto the casing tube [(1)], the passage opening [(5)] having, on [the] an inside [(7)], at least one recess [(10)] which is spaced away from [the] end sides [(8, 9)] of the holder [(2)], which end sides lie transversely with respect to [the] a longitudinal direction of the casing tube [(1)], and [in that] wherein the casing tube [(1)] has a locking element which, in the sliding-fit position of the holder [(2)], is shaped radially from [the] a wall of the [said] holder locally at [the] a location of the recess [(10)] by a fluidic internal high pressure and is jammed in the recess [(10)] as a consequence of [its] a shape of the locking element, forming a [nonreleasable] non-releasable joining connection between the holder [(2)] and the casing tube [(1)].

Serial No.: To Be Assigned

12. (AMENDED) [Steering] The steering column according to Claim 11, [characterized in that] wherein the locking element bears over [the] an entire surface against [the] a wall defining the recess [walls (14)].

13. (AMENDED) [Steering] The steering column according to Claim 11, [characterized in that] wherein the recess [(10)] is formed by an annular groove and the locking element is formed by an annular bead [(17)].

14. (AMENDED) [Steering] The steering column according to Claim 11, [characterized in that] wherein the casing tube [(1)] consists of a ductile steel material, preferably of St 37 or St 52, and the holder [(2)] consists of a casting material or of an injection [moulding] molding or die casting, preferably of ZnAl4Cu, or of a low-strength steel or of a light metal material.

15. (AMENDED) [Steering] The steering column according to Claim 11, [characterized in that] wherein the recess [(10)] is of curved design with a shallow rise from [its] a base [(15) as far as its edges (16)] to opposing edges of the recess.

10/018776 DEC 27 2001
JCIS Rec'd PCT/PTO

Attorney Docket: 225/50785
PATENT #6

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: BERND FREIWALD ET AL.

Serial No.: To Be Assigned

Filed: December 27, 2001 PCT No.: PCT/EP00/04895)

Title: JOINING CONNECTION, METHOD FOR PRODUCING THE
SAME AND A STEERING COLUMN FOR MOTOR VEHICLES
COMPRISING SUCH A JOINING CONNECTION

SUBMISSION OF SUBSTITUTE SPECIFICATION

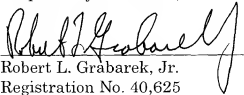
Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

Attached is a Substitute Specification and a marked-up copy of the original specification. I certify that said substitute specification contains no new matter and includes the changes indicated in the marked-up copy of the original specification.

Respectfully submitted,

Date: December 27, 2001


Robert L. Grabarek, Jr.
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CAM No.: 95309.281

2/ppts

Docket No.: 225/50785
Specification – Clean Copy

TITLE OF THE INVENTION

JOINING CONNECTION, METHOD FOR PRODUCING THE
SAME AND A STEERING COLUMN OF MOTOR VEHICLES
COMPRISING SUCH A JOINING CONNECTION

BACKGROUND AND SUMMARY OF THE INVENTION

[0001] This application claims the priority of German Patent Document 199 29 957.9, filed June 29, 1999, and International Application No. PCT/EP00/04895, filed May 30, 2000, the disclosures of which are expressly incorporated by reference herein.

[0002] The invention relates to a joining connection and to a method for producing the same, and to a steering column of a motor vehicle.

[0003] A generic steering column is disclosed in German Patent Document DE 36 00 134 C1 whose casing tube, which consists of plastic, has injection molded integrally on it a holder for the securing of a steering column switch. The outlay on the engineering of the mold is very considerable in this case, since the injection mold has to be of very complex design. Furthermore, because of the stiffness required by the casing tube, the plastic of the casing tube is very brittle and is therefore easily breakable in the event of a crash, which may mean serious consequences in terms of health for the vehicle occupants, in particular for the driver.

[0004] In various applications, components which are exactly aligned with one another have to be secured on a hollow profile or a tube, the securing between the component and tube, i.e., the joining connection, having to

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Specification - Clean Copy

withstand axial displacement forces and torsional moments. One possible joining technique is the internal high-pressure deformation technique which is used in the production of frictional connections between the component and tube, for example in the case of engineered camshafts. In this case, the components to be joined, namely the cam and tube, are first positioned with respect to each other and then the tube is partially acted upon by means of internal high pressure - delivered via an expansion lance inserted into the tube - below the cam. This results successively in flowing of the tube material, in expansion and bearing of the tube material against the cam and in the common expansion of the tube material and cam material. The pressure is set in such a manner that the cam can spring back elastically after it has been relieved of pressure. The springing-back together with a simultaneous, permanent increase in diameter of the tube enables a virtually nonreleasable, frictional joining connection to be achieved. However, a precondition for this type of joining connection is that the yield strength of the joining part, the cam, is greater than the yield strength of the tube. However, if the yield-strength ratios are reversed, the internal high pressure, which acts in an expansive manner, causes the joining part to explode relatively rapidly.

[0005] A generic joining connection and a method for production thereof is also disclosed in German Patent Document DE-A-2 400 148, in which a tube is slid through a hole in a tube plate and, after insertion into the tube of a probe provided with axially spaced sealing rings, is subjected to a pressurized liquid

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via a duct of the probe which first runs axially and then radially between the sealing rings. The tube is thereby expanded and becomes positioned against the hole wall of the tube plate, in which case only the surrounding region of a weld, which has been undertaken on the end side between the tube and tube plate, remains recessed. In order to obtain higher withdrawal forces, widened portions lying one behind another in the hole wall are incorporated, with the result that during the hydraulic expansion of the tube a form-fitting connection also comes about together with – as seen in the axial direction – undercuts which result in the tube becoming jammed in the hole of the tube plate. In this case, it is disadvantageous that the tube material is first of all positioned against the hole wall and only then is pressed into the widened portions, since the premature bearing enables friction to occur between the tube and the hole wall, the friction obstructing further flow of material into the widened portions. In this connection, depending on the depth of the widened portions, the material can become thinned at this point to such an extent that the tube may burst and the production reliability is thus not ensured as desired. Furthermore, the use of material for the tube plate is restricted, since, when a material having a lower yield strength than the material of the tube is used, after bearing of the tube against the hole wall the tube plate would inevitably break during further expansion into the widened portions.

[0006] The present invention is based on the object of finding a joining connection and a method for the production thereof, with which a hollow profile

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and an add-on part having a lower yield strength than the hollow profile can be connected non-releasably to each other in a simple, reproducible and reliable manner. Furthermore, a generic steering column is to be developed in such a manner that a holder can be reliably fitted as an add-on part to the casing tube of the steering column, the holder having a lower yield strength than the casing tube, with a low outlay on components and costs and with an exactly reproducible positioning of the two joining partners with respect to each other in the joining connection.

[0007] In accordance with the invention, because of the local expansion of the hollow profile into the recess of the add-on part and because of the bearing of the hollow profile under pre-stress as a consequence of the more extensive expansion, the add-on part obtains, at least at some points or in subregions of the recess walls of the add-on part, axial fixing and at the same time a rotationally fixed connection on the hollow profile. The non-releasable jamming of the add-on part to the hollow profile, the jamming being achieved in a simple manner merely by application of an internal high pressure in the hollow profile, requires neither additional securing elements nor a high outlay on apparatus and fitting outlay. Since the reliability of the joining method is ensured in the case of the material of the add-on part or holder, which material is low in strength (has a low yield strength) and as a result virtually does not spring back elastically after deformation, but rather is very susceptible to fracturing during the deformation, the arrangement of the recess and spacing of it away from the

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end sides of the add-on part or holder, which end sides lie transversely with respect to the longitudinal extent of the hollow profile or casing tube, ensure that the hollow profile material can flow into the recess without immediately resulting in an excessive contact stress acting in the radial preferred direction between the hollow profile and the add-on part, which stress would destroy the add-on part. The contact pressure of the hollow profile against the add-on part, which pressure arises in the bearing in the recess, is of a sufficient size to be able to transmit torsional moments within certain limits and therefore to achieve a sufficient torsional rigidity of the joining connection, but in turn is not so great that the add-on part - as mentioned above - would be destroyed by exploding.

[0008] Furthermore, the two joining partners, e.g., the hollow profile and add-on part, in the joining connection are, as a result of the joining using internal high pressure, coordinated with each other in a very exact and reproducible manner in their relative axial and radial positioning with respect to each other, with the result that the joining connection is virtually tolerance-free. This is of considerable importance especially when considering the tolerances of the entire construction arrangement in which the joining connection is situated, for example, the steering column.

[0009] In order to compensate for the shortening of the hollow profile during the expansion, the length of the starting part has to be dimensioned to be correspondingly larger in size. Moreover, the holder for the steering column

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switch in the steering column is merely representative of all possible, conceivable holders on the steering column, for example, a holder for securing the steering column on the dashboard or on a transverse support.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Other features of the invention are evident from the dependent claims. Moreover, the invention is explained in greater detail below with reference to an exemplary embodiment illustrated in the drawings, in which:

[0011] Fig. 1a shows, in a perspective view, a section of a tubular hollow profile;

[0012] Fig. 1b shows, in a perspective view, an add-on part of the joining connection according to the invention;

[0013] Fig. 2 shows, in a perspective view, a holder of the steering column according to the invention;

[0014] Fig. 3 shows, in a lateral section, the add-on part from Fig. 1b in a plug-in connection according to the principles of the invention together with the hollow profile from Fig. 1a before the internal high-pressure deformation process; and

[0015] Fig. 4 shows, in a lateral section, the plug-in connection from Fig. 3 after the internal high-pressure deformation process.

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DETAILED DESCRIPTION OF THE DRAWINGS

[0016] Fig. 1a illustrates a circumferentially closed hollow profile 1 which consists of a ductile steel material, preferably of St 37 or St 52. Fig. 1b shows an add-on part 2 which enters into the joining connection according to the invention together with the hollow profile 1. The add-on part 2 is of annular design and consists of a low-strength casting material, of a die casting or injection molding, preferably of ZnAl4Cu1, or of a low-strength steel or of a light metal material. The material is selected in such a manner that in each case it has a lower yield strength than that of the hollow profile 1. In this exemplary embodiment, the add-on part 2 has, at one end, an annular flange 3, from the center of which an introductory stub 4 having a passage opening 5 protrudes vertically. The annular flange 3 has two securing holes 6 which lie diametrically opposite each other and via which the add-on part 2, or after the joining process also the hollow profile 1, are attached to the periphery of the joining bond of hollow profile 1 and add-on part 2 - in a manner fixed on the bodywork in the event of the joining bond being used in the body shell of a motor vehicle - or are secured on the joining bond via the further components. A recess 10, which may be an annular freely turned recess, is formed on the inside 7 of the passage opening 5, said recess being spaced away from the end sides 8, 9 of the add-on part 2, which end sides lie, in the sliding-fit position, transversely with respect to the longitudinal direction of the hollow profile 1 which is to be inserted.

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[0017] The hollow profile 1 may, for example, be a casing tube of a steering column of a motor vehicle, which tube surrounds the steering spindle of the steering column. The steering column has a plurality of holders which form the add-on parts 2. One of these holders can be seen in Fig. 2, which holder, in a departure from the above-mentioned add-on part 2, does not have an annular flange 3, but rather consists of a ring 11 which is to be approximately equivalent to the introductory stub 4 and at whose outer circumference a material tab 12 protrudes downwards. This material tab 12 is of tong-shaped design at its free end 13 and serves as a securing element for a steering column switch.

[0018] The production of the joining connection is further described in connection with Figs. 3 and 4. First, the selection of the materials of the joining partners hollow profile 1 and add-on part 2 is important. In this case, the hollow profile 1 consists of a ductile material which can be reliably expanded during the subsequent internal high-pressure deformation process. Most types of steel are conceivable for this purpose. The hollow profile 1 may be drawn or rolled from a sheet blank and then welded along the longitudinal seam. From the aspect of lightweight construction, in the design of the add-on part 2, use is generally made of a material which has a lower yield strength than the material of the hollow profile 1. The add-on part 2 is generally of a complicated design, depending on purpose and requirements, and so it is favorable, from the point of view of cost and against the background of a low outlay on mold and work, to

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cast or injection mold the add-on part 2 as a light metal cast part having a discarded core. Similarly, it can be formed by forging a lightweight steel.

[0019] In the case of production as a cast part, the recess 10 of the add-on part 2 is cast at the same time or is incorporated, preferably freely turned, in a subsequent machining process. If the add-on part 2 is forged, the recess 10 can subsequently be engraved, turned or milled out. The add-on part 2 is slid with its passage opening 5 onto the hollow profile 1 at the designated joining location, as shown in Fig. 3.

[0020] In the sliding-fit position reached, an expansion lance is then inserted into the hollow profile 1, said expansion lance having an axial hole with a fluid high- pressure generating system connected at one end and in front of which, at the other end, there branches off at least one radial duct with a discharging hole on the outer circumference of the expansion lance. The discharging hole is surrounded by two annular seals which are spaced apart axially and are arranged on the expansion lance. The expansion lance is inserted into the hollow profile 1 sufficiently far such that the discharging hole lies at the location of the recess 10 of the add-on part 2 surrounding the hollow profile 1. A pressurized fluid is then conducted via the axial hole and the radial holes of the expansion lance onto the inside of the hollow profile 1 which is expanded locally there on account of the very high fluid pressure (> 700 bar) and because of its ductility.

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[0021] The hollow profile material flows in this case into the recess 10 and comes to lie on the walls 14 thereof. This may take place at some points or, as can be seen from Fig. 4, with complete, form-fitting bearing. In both cases, the add-on part 2 is fixed in an axially non-releasable manner on the hollow profile 1 and is also held in a rotationally fixed manner thereon on account of the frictional connection at the bearing points. This is optimal in the case of a complete form-fitting connection, i.e., exact bearing of the hollow profile 1 against the recess walls 14 of the add-on part 2. In order to obtain the connection in a simple manner and without a subsequent calibration step which may impair the material and is therefore not reliable, the recess 10 is of curved design with a shallow rise from its base 15 as far as its edges 16 in accordance with the shaping characteristics of a free expansion of the hollow profile 1. The free expansion is distinguished in that the hollow profile 1 forms a bearing contact with the joining partner, the add-on part 2, only at the end of the expansion.

[0022] In the present invention, the expansion of the hollow profile wall on the hollow profile 1 by means of internal high pressure results in the formation of a locking element which bears over the entire surface against the recess walls 14 and jams the hollow profile 1 immovably to the add-on part 2. In this exemplary embodiment, the locking element is formed by an annular bead 17 in accordance with the design of the recess 10 as an annular groove. Otherwise, it is conceivable to form on the inside 7 one or more hollows distributed over the circumference thereof, in place of the annular groove. This has the advantage

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that the form-fitting connection achieved after the internal high-pressure deformation is also effective in a radially directed fixing of the add-on part 2 on the hollow profile 1, with the result that the frictional connection in the locking plays only a subordinate role here and, as a result, even higher torsional moments than in the preceding exemplary embodiment can be absorbed. A further improvement in the durability of the joining connection with respect to mechanical loads can be achieved by roughening the inside 7 of the add-on part 2 or holder, in which the wall material of the hollow profile 1, which material flows while being subjected to the internal high pressure, can then become wedged with microprecision via the locking element.

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TITLE OF THE INVENTION

JOINING CONNECTION, METHOD FOR PRODUCING THE
SAME AND A STEERING COLUMN OF MOTOR VEHICLES
COMPRISING SUCH A JOINING CONNECTION

[Joining connection and a method for producing the same, and steering column
of motor vehicles]

BACKGROUND AND SUMMARY OF THE INVENTION

[0001] This application claims the priority of German Patent Document 199
29 957.9, filed June 29, 1999, and International Application No.
PCT/EP00/04895, filed May 30, 2000, the disclosures of which are expressly
incorporated by reference herein.

[0002] The invention relates to a joining connection [according to the
precharacterizing clause of Patent Claim 1] and to a method for producing the
same, [according to the precharacterizing clause of Patent Claim 6,] and to a
steering column of a motor [vehicles] vehicle [according to the precharacterizing
clause of Patent Claim 11].

[0003] A generic steering column [of the generic type] is disclosed in
German Patent Document DE 36 00 134 C1 whose casing tube, which consists of
plastic, has injection [moulded] molded integrally on it a holder for the securing
of a steering column switch. The outlay on the engineering of the [mould] mold is
very considerable in this case, since the injection [mould] mold has to be of very
complex design. Furthermore, because of the stiffness required by the casing
tube, the plastic of the casing tube is very brittle and is therefore easily

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breakable in the event of a crash, which may mean serious consequences in terms of health for the vehicle occupants, in particular for the driver.

[0004] In various applications, components which are exactly aligned with one another have to be secured on a hollow profile or a tube, the securing between the component and tube, i.e., the joining connection, having to withstand axial displacement forces and torsional moments. One possible joining technique is the internal high-pressure deformation technique which is used in the production of frictional connections between the component and tube, for example in the case of engineered camshafts. In this case, [first of all] the components to be joined, namely the cam and tube, are first positioned with respect to each other and then the tube is partially acted upon by means of internal high pressure - delivered via an expansion lance inserted into the tube - below the cam. This results successively in flowing of the tube material, in expansion and bearing of the tube material against the cam and in the common expansion of the tube material and cam material. The pressure is set in such a manner that the cam can spring back elastically after it has been relieved of pressure. The springing-back together with a simultaneous, permanent increase in diameter of the tube enables a virtually nonreleasable, frictional joining connection to be achieved. However, a precondition for this type of joining connection is that the yield strength of the joining part, the cam, is greater than the yield strength of the tube. However, if the yield-strength ratios are reversed,

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the internal high pressure, which acts in an expansive manner, causes the joining part to explode relatively rapidly.

[0005] A generic joining connection [of the generic type] and a method for production thereof is also disclosed in German Patent Document DE-A-2 400 148, in which a tube is slid through a hole in a tube plate and, after insertion into the tube of a probe provided with axially spaced sealing rings, is subjected to a pressurized liquid via a duct of the probe which first [of all] runs axially and then radially between the sealing rings. The tube is thereby expanded and becomes positioned against the hole wall of the tube plate, in which case only the surrounding region of a weld, which has been undertaken on the end side between the tube and tube plate, remains recessed. In order to obtain higher withdrawal forces, widened portions lying one behind another in the hole wall are incorporated, with the result that during the hydraulic expansion of the tube a form-fitting connection also comes about together with – as seen in the axial direction – undercuts which result in the tube becoming jammed in the hole of the tube plate. In this case, it is disadvantageous that the tube material is first of all positioned against the hole wall and only then is pressed into the widened portions, since the premature bearing enables friction to occur between the tube and the hole wall, the friction obstructing further flow of material into the widened portions. In this connection, depending on the depth of the widened portions, the material can become thinned at this point to such an extent that the tube may burst and the production reliability is thus not ensured

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as desired. Furthermore, the use of material for the tube plate is restricted, since, when a material having a lower yield strength than the material of the tube is used, after bearing of the tube against the hole wall the tube plate would inevitably break during further expansion into the widened portions.

[0006] The present invention is based on the object of finding a joining connection and a method for the production thereof, with which a hollow profile and an add-on part having a lower yield strength than the hollow profile can be connected [nonreleasably] non-releasably to each other in a simple, reproducible and reliable manner. Furthermore, a generic steering column [of the generic type] is to be developed in such a manner that a holder can be reliably fitted as an add-on part to the casing tube of the steering column, [said] the holder having a lower yield strength than the casing tube, with a low outlay on components and costs and with an exactly reproducible positioning of the two joining partners with respect to each other in the joining connection.

[0007] [The object is achieved according to the invention by the features of Patent Claim 1 with regard to the joining connection, by the features of Patent Claim 6 with regard to the method for production thereof, and by the features of Patent Claim 11 with respect to the steering column.]

[0008] [By means of] In accordance with the invention, because of the local expansion of the hollow profile into the recess of the add-on part and because of the bearing of the hollow profile under [prestress] pre-stress as a consequence of

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the more extensive expansion, the add-on part obtains, at least at some points or in subregions of the recess walls of the add-on part, axial fixing and at the same time a rotationally fixed connection on the hollow profile. The [nonreleaseable] non-releasable jamming of the add-on part to the hollow profile, [said] the jamming [therefore] being achieved in a simple manner merely by application of an internal high pressure in the hollow profile, requires neither additional securing elements nor a high outlay on apparatus and fitting outlay. Since the reliability of the joining method is ensured in the case of the material of the add-on part or holder, which material is low in strength (has a low yield strength) and as a result virtually does not spring back elastically after deformation, but rather is very susceptible to fracturing during the deformation, the arrangement of the recess and spacing of it away from the end sides of the add-on part or holder, which end sides lie transversely with respect to the longitudinal extent of the hollow profile or casing tube, ensure that the hollow profile material can flow into the recess without immediately resulting in an excessive contact stress acting in the radial preferred direction between the hollow profile and the add-on part, which stress would destroy the add-on part. The contact pressure of the hollow profile against the add-on part, which pressure arises in the bearing in the recess, is of a sufficient size to be able to transmit torsional moments within certain limits and therefore to achieve a sufficient torsional rigidity of the joining connection, but in turn is not so great that the add-on part - as mentioned above - would be destroyed by exploding.

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[0009] Furthermore, the two joining partners, e.g., the hollow profile and add-on part, in the joining connection are, [by means] as a result of the joining using internal high pressure, coordinated with each other in a very exact and reproducible manner in [respect of] their relative axial and radial positioning with respect to each other, with the result that the joining connection is virtually tolerance-free. This is of considerable importance especially [in respect of] when considering the tolerances of the entire [constructional] construction arrangement in which the joining connection is situated, for example, the steering column.

[0010] In order to compensate for the shortening of the hollow profile during the expansion, the length of the starting part has to be dimensioned to be correspondingly larger in size. Moreover, the holder for the steering column switch in the steering column is merely representative of all possible, conceivable holders on the steering column, for example, a holder for securing the steering column on the dashboard or on a transverse support.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] [Expedient refinements] Other features of the invention [can be gathered] are evident from the [subclaims; moreover] dependent claims. Moreover, the invention is explained in greater detail below with reference to an exemplary embodiment illustrated in the drawings, in which:

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[0012] Fig. 1a shows, in a perspective view, a section of a tubular hollow profile[.];

[0013] Fig. 1b shows, in a perspective view, an add-on part of the joining connection according to the invention[.];

[0014] Fig. 2 shows, in a perspective view, a holder of the steering column according to the invention[.];

[0015] Fig. 3 shows, in a lateral section, the add-on part from Fig. 1b in a plug-in connection according to the principles of the invention together with the hollow profile from Fig. 1a before the internal high-pressure deformation process[.]; and

[0016] Fig. 4 shows, in a lateral section, the plug-in connection from Fig. 3 after the internal high-pressure deformation process.

DETAILED DESCRIPTION OF THE DRAWINGS

[0017] Fig. 1a illustrates a circumferentially closed hollow profile 1 which consists of a ductile steel material, preferably of St 37 or St 52. Fig. 1b shows an add-on part 2 which enters into the joining connection according to the invention together with the hollow profile 1. The add-on part 2 is of annular design and consists of a low-strength casting material, of a die casting or injection [moulding] molding, preferably of ZnAl4Cu1, or of a low-strength steel or of a light metal material. The material is selected in such a manner that in each case

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it has a lower yield strength than that of the hollow profile 1. In this exemplary embodiment, the add-on part 2 has, at one end, an annular flange 3, from the [centre] center of which an introductory stub 4 having a passage opening 5 protrudes vertically. The annular flange 3 has two securing holes 6 which lie diametrically opposite each other and via which the add-on part 2, or after the joining process also the hollow profile 1, are attached to the periphery of the joining bond of hollow profile 1 and add-on part 2 - in a manner fixed on the bodywork in the event of the joining bond being used in the body shell of a motor [vehicles] vehicle - or are secured on the joining bond via the further components. A recess 10, which may be an annular freely turned recess, is formed on the inside 7 of the passage opening 5, said recess being spaced away from the end sides 8, 9 of the add-on part 2, which end sides lie, in the sliding-fit position, transversely with respect to the longitudinal direction of the hollow profile 1 which is to be inserted.

[0018] The hollow profile 1 may, for example, be a casing tube of a steering column of a motor [vehicles] vehicle, which tube surrounds the steering spindle of the steering column. The steering column has a plurality of holders which form the add-on parts 2. One of these holders can be seen in Fig. 2, which holder, in a departure from the [abovementioned] above-mentioned add-on part 2, does not have an annular flange 3, but rather consists of a ring 11 which is to be approximately equivalent to the introductory stub 4 and at whose outer circumference a material tab 12 protrudes downwards. This material tab 12 is of

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tong-shaped design at its free end 13 and serves as a securing element for a steering column switch.

[0019] The production of the joining connection [can essentially be gathered from] is further described in connection with Figs. 3 and 4. First [of all], the selection of the materials of the joining partners hollow profile 1 and add-on part 2 is important. In this case, the hollow profile 1 [is to consist] consists of a ductile material which can be reliably expanded during the subsequent internal high-pressure deformation process. Most types of steel are conceivable for this purpose. The hollow profile 1 may be drawn or rolled from a sheet blank and then welded along the longitudinal seam. From the aspect of lightweight construction, in the design of the add-on part 2, use is generally made of a material which has a lower yield strength than the material of the hollow profile 1. The add-on part 2 is generally of a complicated design, depending on purpose and requirements, and so it is [favourable] favorable, from the point of view of cost and against the background of a low outlay on [mould] mold and work, to cast or injection [mould] mold the add-on part 2 as a light metal cast part having a discarded core. Similarly, it can be formed by forging a lightweight steel.

[0020] In the case of production as a cast part, the recess 10 of the add-on part 2 is cast at the same time or is incorporated, preferably freely turned, in a subsequent machining process. If the add-on part 2 is forged, the recess 10 can subsequently be engraved, turned or milled out. The add-on part 2 is slid with its

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passage opening 5 onto the hollow profile 1 at the designated joining location,
[(Fig. 3)] as shown in Fig. 3.

[0021] In the sliding-fit position reached, an expansion lance is then inserted into the hollow profile 1, said expansion lance having an axial hole with a fluid high- pressure generating system connected at [its] one end and in front of which, at the other end, there branches off at least one radial duct with a discharging hole on the outer circumference of the expansion lance. The discharging hole is surrounded by two annular seals which are spaced apart axially and are arranged on the expansion lance. The expansion lance is inserted into the hollow profile 1 sufficiently far [for] such that the discharging hole [to come to lie] lies at the location of the recess 10 of the add-on part 2 surrounding the hollow profile 1. A pressurized fluid is then conducted via the axial hole and the radial holes of the expansion lance onto the inside of the hollow profile 1 which is expanded locally there on account of the very high fluid pressure (> 700 bar) and because of its ductility.

[0022] The hollow profile material flows in this case into the recess 10 and comes to lie on the walls 14 thereof. This may take place at some points or, as can be seen from Fig. 4, with complete, form-fitting bearing. In both cases, the add-on part 2 is fixed in an axially [nonreleasable] non-releasable manner on the hollow profile 1 and is also held in a rotationally fixed manner thereon on account of the frictional connection at the bearing points. This is optimal in the

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case of a complete form-fitting connection, i.e., exact bearing of the hollow profile 1 against the recess walls 14 of the add-on part 2. In order to obtain [said] the connection in a simple manner and without a subsequent calibration step which may impair the material and is therefore not reliable, the recess 10 is of curved design with a shallow rise from its base 15 as far as its edges 16 in accordance with the shaping characteristics of a free expansion of the hollow profile 1. The free expansion is distinguished in that the hollow profile 1 forms a bearing contact with the joining partner, the add-on part 2, only at the end of the expansion.

[0023] [All in all] In the present invention, the expansion of the hollow profile wall on the hollow profile 1 by means of internal high pressure results in the formation of a locking element which bears over the entire surface against the recess walls 14 and jams the hollow profile 1 immovably to the add-on part 2. In this exemplary embodiment, the locking element is formed by an annular bead 17 in accordance with the design of the recess 10 as an annular groove. Otherwise, it is conceivable to form on the inside 7 one or more hollows distributed over the circumference thereof, in place of the annular groove. This has the advantage that the form-fitting connection achieved after the internal high-pressure deformation is also effective in a radially directed fixing of the add-on part 2 on the hollow profile 1, with the result that the frictional connection in the locking plays only a subordinate role here and, as a result, even higher torsional moments than in the preceding exemplary embodiment

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can be absorbed. A further improvement in the durability of the joining connection with respect to mechanical loads can be achieved by roughening the inside 7 of the add-on part 2 or holder, in which the wall material of the hollow profile 1, which material flows while being subjected to the internal high pressure, can then become wedged with microprecision via the locking element.

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Joining connection and a method for producing the same,
and steering column of motor vehicles

- 5 The invention relates to a joining connection and to a method for producing the same, and to a steering column of motor vehicles according to the precharacterizing clause of Patent Claim 11.

A steering column of the generic type is disclosed in DE
10 36 00 134 C1 whose casing tube, which consists of plastic, has injection moulded integrally on it a holder for the securing of a steering column switch. The outlay on the engineering of the mould is very considerable in this case, since the injection mould has to be of very
15 complex design. Furthermore, because of the stiffness required by the casing tube, the plastic of the casing tube is very brittle and is therefore easily breakable in the event of a crash, which may mean serious consequences in terms of health for the vehicle occupants, in
20 particular for the driver.

In various applications, components which are exactly aligned with one another have to be secured on a hollow profile or a tube, the securing between the component and tube, i.e. the joining connection, having to withstand
25 axial displacement forces and torsional moments. One possible joining technique is the internal high-pressure deformation technique which is used in the production of frictional connections between the component and tube, for example in the case of engineered camshafts. In this
30 case, first of all the components to be joined, namely the cam and tube, are positioned with respect to each other and then the tube is partially acted upon by means

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of internal high pressure - delivered via an expansion lance inserted into the tube - below the cam. This results successively in flowing of the tube material, in expansion and bearing of the tube material against the cam and in the common expansion of the tube material and cam material. The pressure is set in such a manner that the cam can spring back elastically after it has been relieved of pressure. The springing-back together with a simultaneous, permanent increase in diameter of the tube enables a virtually nonreleasable, frictional joining connection to be achieved. However, a precondition for this type of joining connection is that the yield strength of the joining part, the cam, is greater than the yield strength of the tube. However, if the yield-strength ratios are reversed, the internal high pressure, which acts in an expansive manner, causes the joining part to explode relatively rapidly.

The invention is based on the object of finding a joining connection and a method for the production thereof, with which a hollow profile and an add-on part having a lower yield strength than the hollow profile can be connected nonreleasably to each other in a simple, reproducible and reliable manner. Furthermore, a steering column of the generic type is to be developed in such a manner that a holder can be reliably fitted as an add-on part to the casing tube of the steering column, said holder having a lower yield strength than the casing tube, with a low outlay on components and costs and with an exactly reproducible positioning of the two joining partners with respect to each other in the joining connection.

The object is achieved according to the invention by the features of Patent Claim 1 with regard to the joining connection, by the features of Patent Claim 6 with regard to the method for production thereof, and by the features

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of Patent Claim 11 with respect to the steering column.

By means of the invention, because of the local expansion of the hollow profile into the recess and because of the bearing of the hollow profile under prestress as a consequence of the more extensive expansion, the add-on part obtains, at least at some points or in subregions of the recess walls of the add-on part, axial fixing and at the same time a rotationally fixed connection on the hollow profile. The nonreleasable jamming of the add-on part to the hollow profile, said jamming therefore being achieved in a simple manner merely by application of an internal high pressure in the hollow profile, requires neither additional securing elements nor a high outlay on apparatus and fitting outlay. Since the reliability of the joining method is ensured in the case of the material of the add-on part or holder, which material is low in strength (has a low yield strength) and as a result virtually does not spring back elastically after deformation, but rather is very susceptible to fracturing during the deformation, the arrangement of the recess and spacing of it away from the end sides of the add-on part or holder, which end sides lie transversely with respect to the longitudinal extent of the hollow profile or casing tube, ensure that the hollow profile material can flow into the recess without immediately resulting in an excessive contact stress acting in the radial preferred direction between the hollow profile and the add-on part, which stress would destroy the add-on part. The contact pressure of the hollow profile against the add-on part, which pressure arises in the bearing in the recess, is of a sufficient size to be able to transmit torsional moments within certain limits and therefore to achieve a sufficient torsional rigidity of the joining connection, but in turn is not so great that the add-on part - as mentioned above - would be destroyed by exploding.

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Furthermore, the two joining partners, the hollow profile and add-on part, in the joining connection are, by means of the joining using internal high pressure, coordinated with each other in a very exact and reproducible manner

5 in respect of their relative axial and radial positioning with respect to each other, with the result that the joining connection is virtually tolerance-free. This is of considerable importance especially in respect of considering the tolerances of the entire constructional

10 arrangement in which the joining connection is situated, for example the steering column. In order to compensate for the shortening of the hollow profile during the expansion, the length of the starting part has to be dimensioned to be correspondingly larger in size.

15 Moreover, the holder for the steering column switch in the steering column is merely representative of all possible, conceivable holders on the steering column, for example a holder for securing the steering column on the dashboard or on a transverse support.

20 Expedient refinements of the invention can be gathered from the subclaims; moreover, the invention is explained in greater detail below with reference to an exemplary embodiment illustrated in the drawings, in which:

Fig. 1a shows, in a perspective view, a section of a

25 tubular hollow profile,

Fig. 1b shows, in a perspective view, an add-on part of the joining connection according to the invention,

Fig. 2 shows, in a perspective view, a holder of the steering column according to the invention,

30 Fig. 3 shows, in a lateral section, the add-on part from Fig. 1b in a plug-in connection according to the

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invention together with the hollow profile from Fig. 1a before the internal high-pressure deformation process,

Fig. 4 shows, in a lateral section, the plug-in connection from Fig. 3 after the internal high-pressure deformation process.

Fig. 1a illustrates a circumferentially closed hollow profile 1 which consists of a ductile steel material, preferably of St 37 or St 52. Fig. 1b shows an add-on part 2 which enters into the joining connection according to the invention together with the hollow profile 1. The add-on part 2 is of annular design and consists of a low-strength casting material, of a die casting or injection moulding, preferably of ZnAl4Cu, or of a low-strength steel or of a light metal material. The material is selected in such a manner that in each case it has a lower yield strength than that of the hollow profile 1. In this exemplary embodiment, the add-on part 2 has, at one end, an annular flange 3, from the centre of which an introductory stub 4 having a passage opening 5 protrudes vertically. The annular flange 3 has two securing holes 6 which lie diametrically opposite each other and via which the add-on part 2, or after the joining process also the hollow profile 1, are attached to the periphery of the joining bond of hollow profile 1 and add-on part 2 - in a manner fixed on the bodywork in the event of the joining bond being used in the body shell of motor vehicles - or are secured on the joining bond via the further components. A recess 10, which may be an annular freely turned recess, is formed on the inside 7 of the passage opening 5, said recess being spaced away from the end sides 8, 9 of the add-on part 2, which end sides lie, in the sliding-fit position, transversely with respect to the longitudinal direction of the hollow profile 1 to be inserted.

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The hollow profile 1 may, for example, be a casing tube of a steering column of motor vehicles, which tube surrounds the steering spindle of the steering column. The steering column has a plurality of holders which form the add-on parts 2. One of these holders can be seen in Fig. 2, which holder, in a departure from the abovementioned add-on part 2, does not have an annular flange 3, but rather consists of a ring 11 which is to be approximately equivalent to the introductory stub 4 and at whose outer circumference a material tab 12 protrudes downwards. This material tab 12 is of tong-shaped design at its free end 13 and serves as a securing element for a steering column switch.

The production of the joining connection can essentially be gathered from Figs 3 and 4. First of all, the selection of the materials of the joining partners hollow profile 1 and add-on part 2 is important. In this case, the hollow profile 1 is to consist of a ductile material which can be reliably expanded during the subsequent internal high-pressure deformation process. Most types of steel are conceivable for this purpose. The hollow profile 1 may be drawn or rolled from a sheet blank and then welded along the longitudinal seam. From the aspect of lightweight construction, in the design of the add-on part 2 use is generally made of a material which has a lower yield strength than the material of the hollow profile 1. The add-on part 2 is generally of a complicated design, depending on purpose and requirements, and so it is favourable, from the point of view of cost and against the background of a low outlay on mould and work, to cast or injection mould the add-on part 2 as a light metal cast part having a discarded core. Similarly, it can be formed by forging a lightweight steel.

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- In the case of production as a cast part, the recess 10 of the add-on part 2 is cast at the same time or is incorporated, preferably freely turned, in a subsequent machining process. If the add-on part 2 is forged, the recess 10 can subsequently be engraved, turned or milled out. The add-on part 2 is slid with its passage opening 5 onto the hollow profile 1 at the designated joining location (Fig. 3).
- 10 In the sliding-fit position reached, an expansion lance is then inserted into the hollow profile 1, said expansion lance having an axial hole with a fluid high-pressure generating system connected at its one end and in front of which, at the other end, there branches off
- 15 at least one radial duct with a discharging hole on the outer circumference of the expansion lance. The discharging hole is surrounded by two annular seals which are spaced apart axially and are arranged on the expansion lance. The expansion lance is inserted into the
- 20 hollow profile 1 sufficiently far for the discharging hole to come to lie at the location of the recess 10 of the add-on part 2 surrounding the hollow profile 1. A pressurized fluid is then conducted via the axial hole and the radial holes of the expansion lance onto the
- 25 inside of the hollow profile 1 which is expanded locally there on account of the very high fluid pressure (> 700 bar) and because of its ductility.

- The hollow profile material flows in this case into the recess 10 and comes to lie on the walls 14 thereof. This
- 30 may take place at some points or, as can be seen from Fig. 4, with complete, form-fitting bearing. In both cases, the add-on part 2 is fixed in an axially nonreleasable manner on the hollow profile 1 and is also held in a rotationally fixed manner thereon on account of

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the frictional connection at the bearing points. This is optimal in the case of a complete form-fitting connection, i.e. exact bearing of the hollow profile 1 against the recess walls 14 of the add-on part 2. In order to obtain said connection in a simple manner and without a subsequent calibration step which may impair the material and is therefore not reliable, the recess 10 is of curved design with a shallow rise from its base 15 as far as its edges 16 in accordance with the shaping characteristics of a free expansion of the hollow profile 1. The free expansion is distinguished in that the hollow profile 1 forms a bearing contact with the joining partner, the add-on part 2, only at the end of the expansion.

All in all, the expansion of the hollow profile wall on the hollow profile 1 by means of internal high pressure results in the formation of a locking element which bears over the entire surface against the recess walls 14 and jams the hollow profile 1 immovably to the add-on part 2. In this exemplary embodiment, the locking element is formed by an annular bead 17 in accordance with the design of the recess 10 as an annular groove. Otherwise, it is conceivable to form on the inside 7 one or more hollows distributed over the circumference thereof, in place of the annular groove. This has the advantage that the form-fitting connection achieved after the internal high-pressure deformation is also effective in a radially directed fixing of the add-on part 2 on the hollow profile 1, with the result that the frictional connection in the locking plays only a subordinate role here and, as a result, even higher torsional moments than in the preceding exemplary embodiment can be absorbed. A further improvement in the durability of the joining connection with respect to mechanical loads can be achieved by roughening the inside 7 of the add-on part 2 or holder,

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in which the wall material of the hollow profile 1, which material flows while being subjected to the internal high pressure, can then become wedged with microprecision via the locking element.

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DaimlerChrysler AG
Stuttgart

Patent Claims

1. Joining connection between a circumferentially closed
5 hollow profile (1) and an add-on part (2) which is
provided with a passage opening (5), consists of a
material of lower yield strength than the material of the
hollow profile (1) and, on the inside (7) of the passage
opening (5), has a recess (10) which is spaced away from
10 the end sides (8, 9) of the add-on part (2), the add-on
part (2) being slid with its passage opening (5) onto the
hollow profile (1) and being jammed to the latter in this
sliding-fit position by a local expansion of the hollow
profile (1), said expansion being formed by means of
15 internal high-pressure deformation at the location of the
recess (10).

2. Joining connection according to Claim 1, characterized
in that the recess (10) is an annular freely turned
recess.

20 3. Joining connection according to Claim 1, characterized
in that the hollow profile (1) consists of a ductile
steel material, preferably of St 37 or St 52, and the
add-on part (2) consists of a casting material, of a die
casting or injection moulding, preferably of ZnAl4Cu, or
25 of a lower-strength steel or of a light metal material.

4. Joining connection according to Claim 1, characterized
in that the recess (10) is of curved design with a
shallow rise from its base (15) as far as its edges (16).

5. Joining connection according to Claim 1, characterized

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in that the expanded point of the hollow profile (1) bears in an exact manner against the walls (14) of the recess (10).

6. Method for producing a joining connection between a
5 circumferentially closed hollow profile (1) and an add-on part (2) which is provided with a passage opening (5) and consists of a material of lower yield strength than the material of the hollow profile (1), a recess (10) which is spaced away from the end sides (8, 9) of the add-on
10 part (2) being formed on the inside (7) of the passage opening (5), after which the add-on part (2) is slid with its passage opening (5) onto the hollow profile (1), and subsequently the hollow profile (1), in the sliding-fit position reached, is expanded locally into the recess
15 (10), by a fluidic internal high pressure by means of an expansion lance inserted into the hollow profile (1), in such a manner that the hollow profile (1) is jammed immovably to the add-on part (2).

7. Method according to Claim 6, characterized in that the
20 recess (10) is of curved design with a shallow rise from its base (15) as far as its edges (16), and in that the hollow profile (1) is expanded until it bears completely against the recess walls (14).

8. Method according to Claim 6, characterized in that the
25 add-on part (2) is cast as a cast part having a discarded core, the recess (10) being cast at the same time.

9. Method according to Claim 6, characterized in that the add-on part (2) is injection moulded or die cast and the recess (10) is subsequently freely turned.

30 10. Method according to Claim 6, characterized in that the add-on part (2) is formed, in particular forged, from

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a low-strength steel, and in that the recess (10) is then engraved, turned or milled out.

11. Steering column of motor vehicles having a casing tube which surrounds a steering spindle and forms a hollow profile, and a holder, constituting an add-on part, for example for a steering column switch, the holder being joined onto the casing tube, characterized in that the holder (2), which consists of a material of lower yield strength than the material of the casing tube (1), has a circumferentially closed passage opening (5) and is slid with the latter onto the casing tube (1), the passage opening (5) having, on the inside (7), at least one recess (10) which is spaced away from the end sides (8, 9) of the holder (2), which end sides lie transversely with respect to the longitudinal direction of the casing tube (1), and in that the casing tube (1) has a locking element which, in the sliding-fit position of the holder (2), is shaped radially from the wall of the said holder locally at the location of the recess (10) by a fluidic internal high pressure and is jammed in the recess (10) as a consequence of its shape, forming a nonreleasable joining connection between the holder (2) and casing tube (1).

12. Steering column according to Claim 11, characterized in that the locking element bears over the entire surface against the recess walls (14).

13. Steering column according to Claim 11, characterized in that the recess (10) is formed by an annular groove and the locking element is formed by an annular bead (17).

14. Steering column according to Claim 11, characterized in that the casing tube (1) consists of a ductile steel

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material, preferably of St 37 or St 52, and the holder (2) consists of a casting material or of an injection moulding or die casting, preferably of ZnAl4Cu, or of a low-strength steel or of a light metal material.

- 5 15. Steering column according to Claim 11, characterized in that the recess (10) is of curved design with a shallow rise from its base (15) as far as its edges (16).

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Abstract

The invention relates to a joining connection between a circumferentially closed hollow profile and an add-on part which is provided with a passage opening and consists of a material of lower strength than the material of the hollow profile, and to a method for producing the connection and to a steering column having this joining connection. In order to connect a hollow profile and an add-on part having lower strength than the hollow profile nonreleasably to each other in a simple, reproducible and reliable manner, and furthermore in order to reliably fit a holder as an add-on part to the casing tube of the steering column, said holder having lower strength than the casing tube, with a low outlay on components and costs and with exact, reproducible positioning of the two joining partners with respect to each other in the joining connection, it is proposed to provide a recess which is spaced away from the end sides of the add-on part on the inside of the passage opening, to slide the add-on part with its passage opening onto the hollow profile and to jam it to the latter in this sliding-fit position by a local expansion of the hollow profile, said expansion being formed by means of internal high-pressure deformation at the location of the recess.

Crowell & Moring LLP
Customer Service No. 23911

Attorney Docket No. 225/50785
Filed: December 27, 2001
Sheet 1 of 2

Fig. 1a

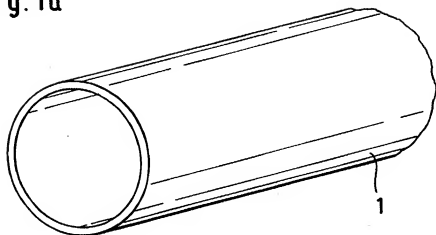
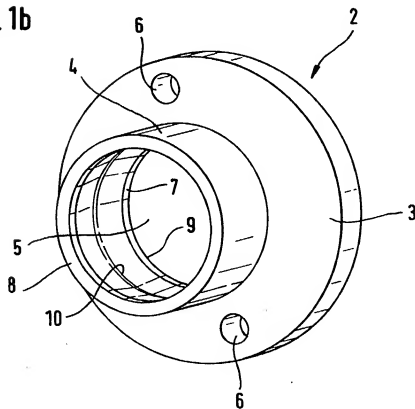


Fig. 1b



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Attorney Docket No. 225/50785
Filed: December 27, 2001
Sheet 2 of 2

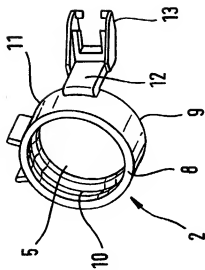


Fig. 2

Fig. 4

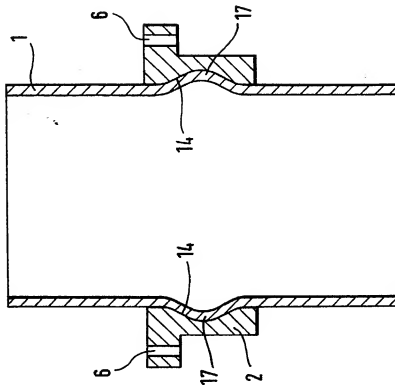
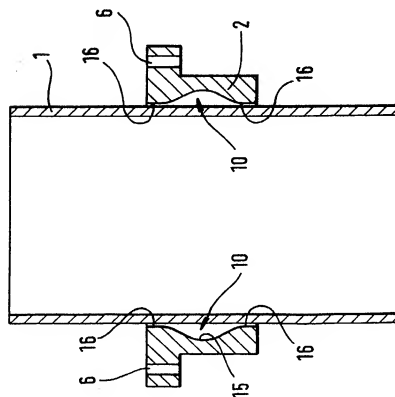


Fig. 3



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**COMBINED DECLARATION FOR PATENT APPLICATION
AND POWER OF ATTORNEY**

(includes Reference to PCT International Applications)

ATTORNEY'S DOCKET NUMBER
225/50785

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

JOINING CONNECTION, METHOD FOR PRODUCING THE SAME AND A STEERING COLUMN FOR MOTOR VEHICLES
COMPRISING SUCH A JOINING CONNECTION

the specification of which (check only one item below):

- ☐ is attached hereto.
- ☐ was filed as United States application
Serial No. _____
on _____
And was amended
on _____ (if applicable).
- ☒ was filed as PCT international application
Number PCT/EP00/04895 on May 30, 2000
and was amended under PCT Article 19
on _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification,
including the claims, as amended by any amendment referred to above.I acknowledge the duty to disclose information which is material to the examination of this application in
accordance with Title 37, Code of Federal Regulations. §1.56(a).I hereby claim foreign priority benefits under Title 35, United State Code, §119 of any foreign application(s)
for patent or inventor's certificate or of any PCT international application(s) designating at least one
country other than the United States of America listed below and have also identified below any foreign
application(s) for patent or inventor's certificate or any PCT international application(s) designating at least
one country other than the United States of America filed by me on the same subject matter having a filing
date before that of the application(s) of which priority is claimed:**PRIOR FOREIGN/PCT APPLICATION(S) AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. 119:**

COUNTRY (if PCT indicate PCT)	APPLICATION NUMBER	DATE OF FILING (day, month, year)	PRIORITY CLAIMED UNDER 35 USC 119
Germany	199 29 957.9	June 29, 1999	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
			<input type="checkbox"/> Yes <input type="checkbox"/> No
			<input type="checkbox"/> Yes <input type="checkbox"/> No
			<input type="checkbox"/> Yes <input type="checkbox"/> No
			<input type="checkbox"/> Yes <input type="checkbox"/> No

Combined Declaration For Patent Application and Power of Attorney (Continued) (includes Reference to PCT international Applications)				ATTORNEY'S DOCKET NUMBER 225050785	
I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) or PCT international application(s) designating the United States of America that I have listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application(s) and the national of PCT international filing date of this application: PRIOR U.S. APPLICATIONS OR PCT INTERNATIONAL APPLICATIONS DESIGNATING THE U.S. FOR BENEFIT UNDER 35 U.S.C. 120					
U.S. APPLICATIONS			STATUS (Check one)		
U.S. APPLICATION NUMBER	U.S. FILING DATE	PATENTED	PENDING	ABANDONED	
PCT APPLICATIONS DESIGNATING THE U.S.					
PCT APPLICATION NO	PCT FILING DATE	U.S. SERIAL NUMBERS ASSIGNED (IF ANY)			
PCT/EP00/04895	May 30, 2000				
POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. (List name and registration number) Herbert I. Cantor, Reg. No. 24,392; James F. McKeown, Reg. No. 25,406; Donald D. Evenson, Reg. No. 26,160; Joseph D. Evans, Reg. No. 26,205; Gary R. Edwards, Reg. No. 31,824; and Jeffrey D. Sznok, Reg. No. 32,169.					
Send Correspondence to: Crowell & Moring, L.L.P., P.O. Box 14300 Washington, D.C. 20044-4300			Direct Telephone Calls to: (name and telephone number) (202) 624-2500		
1-00 201	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME	
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	POST OFFICE ADDRESS	Moisburg	Germany	DEX	
		Hollenstedter Strasse 15	D-21047 Moisburg		
2-00 202	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME	
	RESIDENCE & CITIZENSHIP	Harms	Torsten		
	POST OFFICE ADDRESS	Hamburg	Germany	DEX	
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3-00 203	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME	
	RESIDENCE & CITIZENSHIP	Kahnert	Hartmut		
	POST OFFICE ADDRESS	Neu Wulmstorf	Germany	DEX	
		Stettiner Strasse 9	D-21629 Neu Wulmstorf		
I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.					
SIGNATURE OF INVENTOR 201		SIGNATURE OF INVENTOR 202		SIGNATURE OF INVENTOR 203	
22.01.02 Forwald		Torsten Harms		H. Kahnert	
DATE		Date		DATE	
21.01.2002		21.01.2002		25.01.02	

Combined Declaration For Patent Application and Power of Attorney (Continued) (includes Reference to PCT International Applications)				ATTORNEY'S DOCKET NUMBER 225/50785	
I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application(s) and the national of PCT international filing date of this application:					
PRIOR U.S. APPLICATIONS OR PCT INTERNATIONAL APPLICATIONS DESIGNATING THE U.S. FOR BENEFIT UNDER 35 U.S.C. 120					
U.S. APPLICATION NUMBER	U.S. FILING DATE	PATENTED	PENDING	STATUS (Check one)	
				ABANDONED	
PCT APPLICATIONS DESIGNATING THE U.S.					
PCT APPLICATION NO.	PCT FILING DATE	U.S. SERIAL NUMBERS ASSIGNED (IF ANY)			
PCT/EP00/04895	May 30, 2000				
POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. (List name and registration number)					
Herbert I. Cantor, Reg. No. 24,392; James F. McKeown, Reg. No. 25,406; Donald D. Evenson, Reg. No. 26,160; Joseph D. Evans, Reg. No. 26,269; Gary R. Edwards, Reg. No. 31,824; and Jeffrey D. Sanok, Reg. No. 32,169					
Send Correspondence to: Crowell & Moring, L.L.P. P.O. Box 14300 Washington, D.C. 20044-4300				Direct Telephone Calls to: (name and telephone number) (202) 628-8800	
4-00 204	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME	
		SÄTTLER	Olaf		
	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP	
		Asendorf	Germany	Germany	
	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY		
		Birkhahweg 2	Germany		
	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME	
205					
	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP	
	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY		
	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME	
206					
	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP	
	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY		
I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.					
SIGNATURE OF INVENTOR 204		SIGNATURE OF INVENTOR 205		SIGNATURE OF INVENTOR 206	
DATE		DATE		DATE	
21.01.02					